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Publication date:
2018

Document Version
Peer reviewed version

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As supply chains become more complex and globalized, logistic efficiency is essential for a firm to maintain its competitive strategy. It is well known that a lack of coordination and information sharing among facilities with conflicting objectives is a major cause of large logistic inefficiencies in a supply chain. Therefore, the literature emphasizes that a shift from the traditional approach of localized planning to a global, integrated solution is one way in which systemwide costs can be greatly reduced (Darvish et al., 2016; Guastaroba et al., 2017). Subsequently, a large body of research exists on integrated optimization problems in logistics and supply chain management (e.g. Coelho et al. (2014); Schmid et al. (2013)), and Table 1 summarizes some of the well-known problems that integrate up to three decisions of production, inventory, distribution and facility location.

Problem	**Production**	**Inventory**	**Distribution**	**Location**
Lot Sizing Problem (LSP)	✓	✓		
Inventory-Routing Problem (IRP)		✓	✓	
Production-Routing Problem (PRP)	✓	✓	✓	
Location-Routing Problem (LRP)			✓	✓
Location-Inventory Problem (LIP)		✓		✓

Table 1: Overview of some of the well-known integrated supply chain planning problems (adapted from Adulyasak et al. (2015)).

Theoretically speaking, the feasible region of an integrated approach contains the feasible regions of the localized problems, and therefore always yields a superior solution. In reality, however, integration significantly increases the complexity of the entire decision making process as more coordination and information sharing is needed. In addition, moving from a localized planning approach to an integrated one might require an upgrade in organizational and information infrastructure that impose additional costs. The question naturally arises: how can we quantify the *value of integration* in order to support the strategic decision to shift from localized planning to integrated planning? The concept of the value of integration has been considered before, for example by Darvish and Coelho (2017), who highlight the benefits of integration over sequential/hierarchal approaches to supply chain planning. In this work we continue along this line of research.

Crucial to our research question is that it is not only a matter of *whether or not* to integrate, but also *what* to integrate. Figure 1 shows two approaches to solving the planning problem from Table 1, where the subproblems of location, production, inventory and distribution have to be solved. The model on the left first solves the location problem and then fixes its solution. It then moves on to making and fixing the production decisions and then solving the IRP. The model on the right, however, integrates all decisions in a single optimization problem. The model on the right is "more integrated" than the one on the left, and so the potential for improved performance is higher. Furthermore, from a complexity point of view, the left one might be preferable, depending on the case. Here is where the value of integration will play an important role.

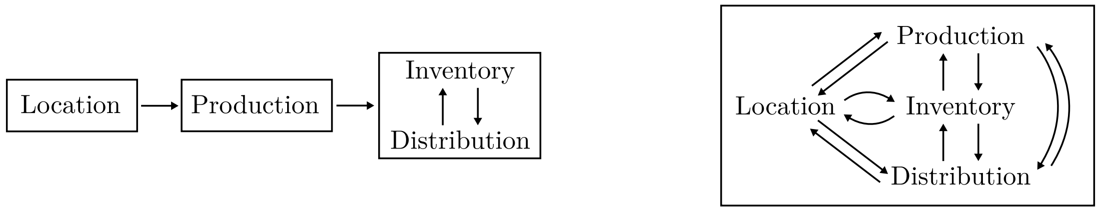

Figure 1: Examples of two different levels of integrated supply chain planning.

In this talk we will present some initial results on data from different industries. In order to compare several possible levels of integration (such as the ones shown in Figure 1), computational tests will be conducted by using mixed integer programming (MIP) formulations of the subproblems, depending on how the integration is done. We will address the question of whether or not there is a relationship between a good way of integrating decisions and certain features of the supply chain.

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